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D E C L A R A T I O N

In the matter of U.S. Patent Application Ser. No. 10/522,155 in the name of Yasuhiro CHOUNO et al.

I, Mariko ENDO, of Kyowa Patent and Law Office, 2-3, Marunouchi 3-Chome, Chiyoda-Ku, Tokyo-To, Japan, declare and say:

that I am thoroughly conversant with both the Japanese and English languages; and,

that the attached document represents a true English translation of Japanese Patent Application No. 2002-216123 filed on July 25, 2002.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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[Title of Invention] Substrate Chamber

[Claims]

[Claim 1]

A substrate processing chamber for supplying to a substrate accommodated therein a predetermined processing gas to process the substrate, comprising;

a plurality of support rods having at a distal end thereof support portions adapted to support a substrate in substantially a horizontal position, with longitudinal directions of the support rods corresponding to vertical directions;

a lifting mechanism that vertically moves the support rods;

a lower vessel having through holes through which the support rods are inserted, the through holes being closed by the support portions when the support rods are lowered to hold the support portions at the lowest end; and

a lid capable of vertically moving, and opening and closing the upper surface of the lower vessel.

[Claim 2]

The substrate processing chamber according to claim 1, further comprising an annular diaphragm for hermetically sealing a gap between an outer periphery of the support rod and a wall surface of the through hole.

[Claim 3]

The substrate processing chamber according to claim 1 or 2,

wherein the lifting mechanism includes:

a cylinder having a cylindrical interior space in communication with the through holes;

a lifting rod connected to the support rods and disposed in the interior space, with an upper and a lower diameters of the lifting rod

being shorter than an intermediate diameter to make two vertically separated separate air chambers;

a first air supply mechanism that sends air into the lower air chamber to raise the lifting rod; and

a second air supply mechanism that sends air into the upper air chamber to lower the lifting rod.

[Claim 4]

The substrate processing chamber according to claim 1 or 2, wherein the lifting mechanism further includes:

a spring for biasing the support rods upward; and

a pressing member disposed on a lower surface of the lid, and separating from or closing to the support portions to expand or construct the spring, when the lid closes the upper surface of the lower vessel.

[Claim 5]

A substrate processing chamber processing chamber for supplying to a substrate accommodated therein a predetermined processing gas to process the substrate, comprising:

a lower vessel;

a lid capable of vertically moving, and opening and closing the upper surface of the lower vessel;

a support member that supports a substrate in substantially a horizontal position;

a spring having one end fixed in the lower vessel and the other end fixed to the support member; and

a pressing member disposed on the support member, and separating from and closing to the lid when the lid is vertically moved;

wherein, when the lid closes the upper surface of the lower vessel, the spring is held in the constructed state by the pressing member in contact with the lid with t support member being pressed downward, and when the lid is spaced apart from the lower vessel, the support member

is raised by an urging force of the spring to thereby a substrate supported on the support member is raised at a predetermined height.

[Claim 6]

A substrate processing chamber for supplying to a substrate accommodated therein a predetermined processing gas to process the substrate, comprising:

a lower vessel having a plurality of through holes in a bottom surface thereof at predetermined positions;

a lid capable of vertically moving, and opening and closing the upper surface of the lower vessel;

a plurality of support rods having at a distal end there of support portions adapted to support a substrate , the support rods being inserted in the through holes;

a rod support member that supports the support rods;

a lifting mechanism that vertically moves the rod support member; and

a cylindrical stretchable gas-leakage prevention member disposed to surround the support rods between the rod support member and the bottom wall of the lower vessel, for preventing a leakage of the processing gas through the through holes to the outside.

[Claim 7]

The substrate processing chamber according to claim 6, further comprising an O-ring that seals a gap between a wall surface of the through hole and an outer peripheral surface of the support rod.

[Claim 8]

The substrate processing chamber according to one of claims 1 to 7,

wherein the bottom surface of the lower vessel and the lid include heaters, respectively.

[Claim 9]

The substrate processing chamber according to one of claims 1 to 8, further comprising a chamber locking mechanism for airtightly holding the lid and the lower vessel, when the lid is lowered to be in contact with the lower vessel.

[Detailed Description of the Invention]

[0001]

The present invention relates to a substrate chamber for processing a substrate, such as a semiconductor wafer or an LCD glass substrate, in a sealed atmosphere.

[Field of the Invention]

[0002]

[Related Art]

Generally, in a semiconductor device manufacturing, a predetermined circuit pattern is formed on a semiconductor wafer (hereinafter referred to simply as "wafer") by photolithography. To be specific, a series of processes for processing a cleaned wafer includes a step of forming a resist film by applying a photoresist liquid on the wafer, a step of exposing the resist film with a predetermined pattern, a step of developing the exposed resist film, a step of etching the wafer and doping the wafer, and a step of removing the resist film from the wafer.

[0003]

A recently proposed method of removing a resist film from a wafer includes steps of changing the properties of the resist film by using a processing gas containing steam and ozone gas, and thereafter washing off the resist film from the wafer by water.

[0004]

Fig. 12 is a schematic sectional view of a chamber 200 for removing a resist by the processing gas. The chamber 200 has a fixed lower vessel 201 and a vertically movable cover 202. The cover 202 is moved vertically

for opening and closing the chamber 200. A stage 203 for placing thereon a wafer W is arranged on the lower vessel 201. The upper surface of the stage 203 is provided with a plurality of support pins 203a for supporting the wafer W. A gas supply port 204 through which a processing gas is supplied into the chamber 200 and a gas discharge port 205 through which the processing gas is discharged are formed in the sidewall of the chamber 200 at opposite positions. Heaters 206a and 206b are embedded in the cover 202 and the stage 203, respectively, to heat the wafer W supported on the support pins 203a at a predetermined temperature.

[0005]

Loading of the wafer W onto the support pins 203a and unloading of the wafer W therefrom is carried out by a carrying arm, not shown.

[0006]

[Problems to be Solved by the Invention]

The support pins 203a of the chamber of such construction must have a length not shorter than 10 mm to enable the carrying arm to transfer the wafer W to and from the support pins 203a smoothly without colliding with the stage 203. Therefore, the processing space in the chamber 200 has a big height and thus a large volume. Consequently, the amount of the processing gas for one processing cycle is large and the running cost is high. Moreover, the processing gas flows irregularly in the chamber and the in-plane uniformity of the process deteriorates. A processing system including a plurality of such chambers is inevitably large.

[0007]

In addition, since the wafer W is spaced a long distance apart from the stage 203, the wafer W cannot be heated efficiently and the throughput is low. Since the temperature distribution in the surface of the wafer W is irregular and hence the in-plane uniformity of the process deteriorates.

[0008]

The present invention has been made in view of the foregoing circumstances and it is therefore an object of the present invention to provide a substrate chamber provided with a substrate support structure that enables forming the substrate chamber in low profile and in a small internal volume. Another object of the present invention is to provide a substrate chamber capable of improving processing uniformity. A further object of the present invention is to provide a substrate chamber capable of increasing throughput.

[0009]

[Means for Solving the Problem]

According to the first aspect of the present invention, there is provided a substrate processing chamber for supplying to a substrate accommodated therein a predetermined processing gas to process the substrate, comprising; a plurality of support rods having at a distal end thereof support portions adapted to support a substrate in substantially a horizontal position, with longitudinal directions of the support rods corresponding to vertical directions; a lifting mechanism that vertically moves the support rods; a lower vessel having through holes through which the support rods are inserted, the through holes being closed by the support portions when the support rods are lowered to hold the support portions at the lowest end; and a lid capable of vertically moving, and opening and closing the upper surface of the lower vessel.

[0010]

The substrate chamber of the present invention does not need any member corresponding to the long substrate support pins, permanently projecting into the processing space, of the conventional substrate chamber. Therefore, the substrate chamber can be designed such that a thin processing space having a small volume and conforming to the shape

of a substrate is defined therein. Thus the amount of the processing gas to be supplied into the substrate chamber can be reduced and the processing gas can be effectively used. Consequently, the running cost of the substrate processing system can be reduced and the throughput can be increased.

[0011]

According to a second aspect of the present invention, there is provided a substrate processing chamber processing chamber for supplying to a substrate accommodated therein a predetermined processing gas to process the substrate, comprising: a lower vessel; a lid capable of vertically moving, and opening and closing the upper surface of the lower vessel; a support member that supports a substrate in substantially a horizontal position; a spring having one end fixed in the lower vessel and the other end fixed to the support member; and a pressing member disposed on the support member, and separating from and closing to the lid when the lid is vertically moved; wherein, when the lid closes the upper surface of the lower vessel, the spring is held in the constructed state by the pressing member in contact with the lid with t support member being pressed downward, and when the lid is spaced apart from the lower vessel, the support member is raised by an urging force of the spring to thereby a substrate supported on the support member is raised at a predetermined height.

[0012]

In the substrate processing chamber, when the lid is withdrawn above the lower vessel, the spring naturally expands to urge the support member. Thus, the substrate supported by the support member is held at a predetermined height position from the lower vessel. On the other hand, when the lid closes the upper surface of the lower vessel, the spring is constructed by a pressing force transferred through the pressing member, and the substrate supported by the support member is held in

the vicinity of the lower vessel. Thus, the substrate processing chamber can have a small content volume, and simultaneously a processing uniformity of substrates can be improved. Since the substrate processing chamber needs not a sealing member for preventing a leakage of the processing gas other than a sealing portion necessary to a gap between the lid and the lower vessel, the substrate processing device is superior in safety.

[0013]

According to a third aspect of the present invention, there is provided a substrate processing chamber for supplying to a substrate accommodated therein a predetermined processing gas to process the substrate, comprising: a lower vessel having a plurality of through holes in a bottom surface thereof at predetermined positions; a lid capable of vertically moving, and opening and closing the upper surface of the lower vessel; a plurality of support rods having at a distal end there of support portions adapted to support a substrate , the support rods being inserted in the through holes; a rod support member that supports the support rods; a lifting mechanism that vertically moves the rod support member; and a cylindrical stretchable gas-leakage prevention member disposed to surround the support rods between the rod support member and the bottom wall of the lower vessel, for preventing a leakage of the processing gas through the through holes to the outside.

[0014]

According to the processing chamber, since its content volume is small, an amount of the processing gas to be used can be reduced, as well as a processing uniformity in substrates can be improved.

[0015]

[Description of the Preferred Embodiments]

Preferred embodiments of the present invention will be described with reference to the accompanying drawings. Herein, a resist removing

system is described that carries out a loading and an unloading operations of a wafer, a process of modifying a resist film formed on a surface of a wafer by a processing gas containing steam and ozone (O_3), and a cleaning process of removing the resist film processed by the modified resist.

[0016]

Fig. 1 is a schematic plan view of a resist removing system, Fig. 2 is a schematic front elevation of the resist removing system, and Fig. 3 is a schematic rear view of the resist removing system. The resist removing system 1 includes a carrier station 4 into which a carrier accommodating a wafer W is loaded from a wafer W from another process system and from which a carrier accommodating a wafer W which has been subjected to a predetermined process in the resist removing system 1 is unloaded to another process system for the succeeding process, a processing station 2 having a plurality of processing units for processing a wafer W by a modification process, a resist removing process succeeding the modification process, and a cleaning and drying process, a conveying station 3 provided with a conveyer for carrying a wafer between the processing station 2 and the carrier station 4, and a chemical station 5 in which chemical liquids and gases to be used in the processing station 2 are prepared and stored.

[0017]

In a carrier C, the wafer W are held in a substantially horizontal position and are vertically (Z direction) arranged at regular intervals. The wafer W is taken out from and put in the carrier C through one side surface of carrier C. The side surface is capable of being opened and closed by a lid 10a (not shown in Fig. 1, and in Figs. 2 and 3, the lid 10a is removed).

[0018]

As shown in Fig. 1, the carrier station 4 is provided with a table

6 capable of supporting three carriers C thereon aligned in Y-direction in Fig. 1. The carrier C is placed on the table 6 with the side surface provided with the lid facing a partitioning wall 8a arranged between the conveying station 3 and the carrier station 4. Windows 9a are formed in the partitioning wall 8a at positions corresponding to locations at which the carriers C are to be placed on the table 6. Shutters 10 are installed at positions respectively corresponding to the windows 9a on the side of the conveying station 3 to close the windows. Each of the shutters 10 is provided with a gripper, not shown, capable of gripping the lid 10a of the carrier C. As shown in Figs. 2 and 3, gripping the lid 10a, the gripper carries the lid 10a into the conveying station 3.

[0019]

A wafer conveyer 7 installed in the conveying station 3 is provided with a wafer pickup device 7a for holding a wafer W. The wafer conveyer 7 is capable of traveling in Y-direction along guide rails 11 (see Figs. 2 and 3) extending in Y-direction. The wafer pickup device 7a is slidable along X-direction, vertically movable along Z-directions, and turnable in X-Y plane (θ-directions).

[0020]

Due to this structure, when the shutter 10 is opened so that the interior of the carrier C communicates with the conveying station 3 through the window 9a, the wafer pickup device 7a is able to access all the wafers W held in the carrier C. Thus, the wafer W at a desired height in the carrier C can be taken out of the carrier C and the wafer W can be delivered to an optional position in the carrier C.

[0021]

The processing station 2 has two wafer holding units (TRS) 13a and 13b on the side of the conveying station 3. For example, the wafer holding unit (TRS) 13b is used for holding the wafer W when the wafer W is delivered from the conveying station 3, while the wafer holding

unit (TRS) 13a is used for holding the processed wafer W when it is returned from the processing station 2 to the conveying station 3. As described below, a filter fan unit (FFU) 18 supplies clean air into the processing station 2 in a down-flow mode. Therefore, the contamination of the processed wafer W held in the upper wafer holding unit 13a can be suppressed.

[0022]

A partitioning wall 8b separating the conveying station 3 and the processing station 2 is provided with windows 9b, which are arranged at locations corresponding respectively to the wafer holding units (TRS) 13a and 13b. The wafer pickup device 7a is able to access the wafer holding units 13a and 13b through the windows 9a. The wafer pickup device 7a is able to carry the wafer W between the carrier C and each of the wafer holding units (TRS) 13a and 13b.

[0023]

The processing station 2 is provided with eight resist modification units (VOS) 15a to 15h, which perform a process for modifying a resist film formed on a wafer W, in a back part in two columns and four levels. The processing station 2 is provided also with four cleaning units (CLN) 12a to 12d for removing a resist film from a wafer W processed by the resist modification units (VOS) 15a to 15b. The cleaning units 12a to 12d are installed in a front part in two columns and two levels. A main wafer conveyer 14 is installed in central part of the processing station 2. The main wafer conveyer 14 carries a wafer W in the processing station 2.

[0024]

In the processing station 2, hot plate units (HP) 19a to 19d for heating a wafer W processed by any one of the cleaning units 12a to 12d to dry the wafer W are disposed opposite to the wafer holding units (TRS) 13a and 13b with respect to the main wafer conveyer 14. The hot plate

units 19a to 19d are stacked in four levels. Cooling plate units (COL) 21a and 21b for cooling a dried wafer W are stacked above the wafer holding unit (TRS) 13a. The wafer holding unit (TRS) 13b may be used as the cooling plate units (COL) 21a and 21b. The filter fan unit (FFU) 18 for sending clean air into the processing station 2 is installed in an upper part of the processing station 2.

[0025]

The main wafer conveyer 14 has a wafer carrying arm 14a for carrying a wafer W. The main wafer conveyer 14 is capable of turning about an axis extending in Z-directions. The wafer carrying arm 14a is movable in horizontal directions and in Z-directions. Due to this structure, the main wafer conveyer 14 is able to access any units of the processing station 2 and carries a wafer W from one to another unit of the processing station 2.

[0026]

The resist modification units (VOS) 15a to 15d and the resist modification units (VOS) 15e to 15h are substantially symmetrical in configuration with respect to a partitioning wall 22b. Each of the resist modification units (VOS) 15a to 15d has a hermetic chamber capable of holding a wafer W in a horizontal position therein. A processing gas containing steam and ozone is supplied into the chamber, whereby a resist film formed on a surface of a wafer W is changed into a easily-removable film.

[0027]

The cleaning units (CLN) 12a and 12b and the cleaning units (CLN) 12c and 12d are substantially symmetrical in configuration with respect to a partitioning wall 22a. This is because the construction of the main wafer conveyer 14 is simplified and the accessing operation of the main wafer conveyer 14 is facilitated. Each of the cleaning units (CLN) 12a to 12d has a spin chuck capable of holding a wafer W and of turning,

a cup surrounding the spin chuck, a cleaning liquid jetting nozzle for jetting a cleaning liquid, such as pure water or an organic solvent, onto the surface of a wafer W held by the spin chuck, and a gas jetting nozzle for jetting a dry gas onto the surface of a wafer W.

[0028]

The chemical station 5 has a processing gas supply unit 16 and a cleaning liquid supply unit 17. The processing gas supply unit 16 prepares a processing gas containing steam and ozone and supplies the processing gas to the resist modification units (VOS) 15a to 15h. The cleaning liquid supply unit 17 stores a cleaning liquid (pure water) to be used by the cleaning units (CLN) 12a to 12d and supplies the same to the cleaning units (CLN) 12a to 12d. The processing gas supply unit 16 is, for example, provided with an ozone generator for converting oxygen into ozone, a nitrogen gas supply line through which nitrogen for diluting ozone and nitrogen for purging the chamber after the modification process of the resist is supplied, a steam generator for converting deionized water into steam, and a mixer for mixing a mixed gas of ozone and nitrogen, and steam to generate a processing gas. The ozone generator may generate a mixed gas of ozone and nitrogen by converting oxygen in air into ozone.

[0029]

The resist modification unit (VOS) 15a will be described. The resist modification unit (VOS) 15a has a hermetic chamber arranged in a case, and adapted to hold a wafer W therein. Figs. 4 and 5 show the chamber 30 according to the present invention in schematic sectional views. Fig. 6 is an enlarged sectional view of the peripheral portion of the chamber 30.

[0030]

The chamber 30 includes a fixed lower vessel 41a and a cover 41b covering the upper surface of the lower vessel 41a. The cover 41b can be moved vertically by a lifting mechanism 42, such as a pneumatic cylinder

actuator, attached to a frame or an upper wall, not shown, constituting the case of the resist modification unit (VOS) 15a. In Figs. 4 and 6, the cover 41b is closely joined to the lower vessel 41a. In Fig. 5, the cover 41b is raised apart from the lower vessel 41a.

[0031]

O-rings 43 are placed on the upper surface of a peripheral part 44c of the lower vessel 41a. The lower surface of a peripheral part 45c of the cover 41b is substantially flat. The cover 41b is lowered so as to compress the O-rings 43 to seal the joint of the lower surface of the peripheral part 45c of the cover 41b and the upper surface of the peripheral part 44c of the lower vessel 41a. Thus, a sealed processing space 32 is formed in the chamber 30.

[0032]

Formed in the peripheral part 44c of the lower vessel 41a are a gas supply port 46a for supplying processing gas containing steam and ozone into the processing space 32, and a gas discharge port 46b for discharging the processing gas used in the processing space 32. Various gases, such as nitrogen gas or a mixed gas of nitrogen gas and ozone, which are to be used for purging the processing space 32 before and after supplying the processing gas into the processing space 32, can be supplied through the gas supply port 46a.

[0033]

In order prevent outflow of the processing gas from the processing space 32 through a contact surface between the lower vessel 41a and the lid 41b, it is preferable to more firmly join the lid 41b and the lower vessel 41a together, in addition to the pressing force by the lifting mechanism 42. Thus, it is preferable to dispose a locking mechanism 35 capable of fastening a periphery 44c of the lower vessel 41a and a periphery 45c of the lid 41b.

[0034]

Fig. 7 is a top plan view showing the lid 41b and the schematic structure and arranged of the locking mechanism 35. The lower vessel 41a and the lid 41b have overlapping shapes when seen from the Z-direction, and are provided with four cutouts. The locking mechanism 35 has four clamping devices 57 synchronously movable along the circumference of the cover 41b. Each of the clamping devices 57 includes clamping rollers 59a and 59b supported for rotation on shafts 58, respectively, and roller holding members 60 holding the shafts 58.

[0035]

Fig. 8 is a view for explaining a motion of the clamping rollers 59a and 59b. The cover 41a can be freely moved in vertical directions while the clamping devices 57 are positioned in the cutouts 61, respectively. When the four clamping devices 57 are turned simultaneously along the circumference of the cover 41b through an angle of 45° about the center axis of the cover 41b, the clamping rollers 59a roll along slopes formed on the upper surfaces of the flanges 45d of the cover 41b, respectively, and the clamping rollers 59b roll along slopes formed on the lower surfaces of the flanges 44d of the lower vessel 41a, respectively. By setting the distance between the corresponding clamping rollers 59a and 59b shorter than the distance between the lower surface of the flange 44d and the upper surface of the flange 45, the lower vessel 41a and the lid 41b can be clamped firmly. Thus, the sealing property of the chamber 30 can be improved.

[0036]

The shafts 58 may be vertically movably supported with springs on the roller holding member 60 to enable the adjustment of pressure exerted by the clamping rollers 59a and 59b. The number of the cutouts 61 is not limited to four as shown in Fig. 7. Preferably, at least three hollows 61 are arranged at equal angular intervals.

[0037]

A stage 44a corresponding to the size of the wafer W is formed in a central part of the lower vessel 41a. An annular groove 44b is formed between the stage 44a and the peripheral part 44c. A plurality of, e.g., three through holes 47 are formed at the annular groove 44b. The through hole 47 has a stepped structure such that a diameter of the lower part is larger than a diameter of the upper part.

[0038]

A support rod 49, which is provided at the tip thereof with a support member 48 for supporting a wafer W thereon, is arranged in each of the through holes 47. The support member 48 may be formed integrally in a single member. Rod lifting mechanisms 50 are attached to the lower surface of the lower vessel 41a.

[0039]

The support member 48 has a body 48a having a top surface for supporting a wafer W thereon and a guide 48b formed on the top surface of the body 48a. The guides 48b restrain a wafer W supported on the bodies 48a from horizontal movement. Each body 48a has a shape of frustum in which the outer diameter in the lower end is shorter than the outer diameter of the body 48a. An upper end part of the through hole 47 has the shape of a frustum to fit to the conical shape of the lower part of the body 48a (see Fig. 6). When the rod lifting mechanism 50 is operated so as to press the support member 48 against the entrance portion of the through hole 47, the through hole 47 is closed in an airtight fashion by the support member 48. Thus the processing gas supplied into the processing space 32 in the chamber 30 is unable to leak outside from the chamber 30 through the through holes 47.

[0040]

Referring to Fig. 6, the rod lifting mechanism 50 includes a cylinder 51 having a cylindrical internal space, and a lifting rod 52 fitted in the internal space. The cylinder 51 and the lifting rod 52 are in a

bedding structure through a bearing 53. The cylinder 51 is disposed on a rear surface of the lower vessel 41a such that the internal space comes in communication with the through hole 47. A lower and an upper outer diameters of the lifting rod 52 are shorter than an outer diameter of the intermediate part. Thus, spaces 54a and 54b are formed in the upper and lower part of the internal space of the cylinder 51.

[0041]

The cylinder 51 is provided with a first air inlet/outlet port 55a connected to the lower space 54a, to which an air supply systems 31a is connected by a pipe. A second air inlet/outlet port 55b is connected to the upper space 54b, to which an air supply systems 31b is connected by a pipe.

[0042]

With the second air inlet/outlet port 55b being opened, when air is supplied through the first air inlet/outlet port 55a into the lower space 54a, the lifting rod 52 elevates. On the other hand with the first air inlet/outlet port 55a being opened, when air is supplied through the second air inlet/outlet port 55b into the upper space 54b, the lifting rod 52 lowers. A projecting part of a larger diameter is arranged at the lower end of the support rod 49. When the projecting part of the support rod 49 comes into contact to the exit portion of the smaller diameter part of the through hole 47, the support rod 49 can no longer elevate, thereby the upper limit position of the support member 48 is determined.

[0043]

Referring to Fig. 5, when the lifting rod 52 is lifted to move the support member 48 upward, the vertical distance between the wafer support surface of the support member 48 and the upper surface of the stage 44a increases. Consequently, the wafer carrying arm 14a is able to transfer a wafer W to and from the support member 48 without colliding

with the lower vessel 41a. As shown in Figs. 4 and 6, when the lifting rod 53 is lowered, the support member 48 closes the upper entrance of the through hole 47, while the wafer W is supported in the vicinity of the stage 44a.

[0044]

The chamber 30 does not need any member corresponding to the long substrate support pins 203a of the conventional chamber 200 shown in Fig. 12. Therefore, the chamber 30 can be formed in a low profile and a small content volume. Furthermore, the lower vessel 41a has the groove 44b for supporting the support members 48, and the stage 44a which is positioned close to the rear surface of the wafer W supported on the support members 48. Thus, the content volume of the processing space 32 can be further reduced. The processing space 32 having a small content volume reduces the necessary amount of the processing gas.

[0045]

As mentioned above, since the support members 48 close the entrance portions of the through holes 47, the processing gas is prevented from leaking outside through the through holes 47. However, to be more careful for unexpected trouble, the chamber 30 has a circular diaphragm 56 for hermetically sealing a gap between outer periphery of the support rod 49 and a wall surface of the through hole 47. An inner peripheral part of the diaphragm 56 is hermetically connected to the support rod 49, and an outer peripheral part of the diaphragm 56 is held between a part, around the lower end of the through hole 47, in the lower surface of the chamber 30 and the upper surface of the cylinder 51. Preferably, the diaphragm 56 is formed of a corrosion-resistant fluorocarbon resin, such as PTFE.

[0046]

A heater 39a is embedded in the stage 44a of the lower vessel 41a so that a wafer W can be heated. When a wafer W is held by the lowered

support member 48, the wafer W can be quickly heated at a desired temperature because the wafer W is supported near the stage 44a. The wafer W can be highly uniformly heated. Thus throughput is improved and the wafers W can be processed in high quality. The cover 41b is provided with a heater 39b. The heater 39b of the cover 41b enables quicker and more uniform heating of a wafer W. The heaters 39a and 39b are not shown in Fig. 6.

[0047]

An example of process steps to be carried out by the resist removing system 1 will be described. A carrier C holding etched wafers W with the use of a resist film as a mask is placed on the table 6 by an operator or an automatic carrying machine. The lid 10a and the shutter 10 are retracted to the side of the transfer station 3 to open the window 9a and. Subsequently, the wafer pickup device 7a conveys a wafer W at a certain position in the carrier C to the wafer holding unit (TRS) 13b.

[0048]

Then, the wafer carrying arm 14a carries the wafer W from the wafer holding unit (TRS) 13b to the resist modification unit (VOS) 15a (or any one of the resist modification units 15b to 15h). The carrying-in of the wafer W to the resist modification unit (VOS) 15a is performed in the following manner. The cover 41b of the chamber 30 is retracted above the lower vessel 41a and is withdrawn to a position above the lower vessel 41a. Thereafter, the rod lifting mechanisms 50 are operated to raise the support members 48. Then, the wafer carrying arm 14a holding the wafer W brings the wafer W to a position above the support members 48, moves down, and withdraws horizontally from the space between the lower vessel 41a and the cover 41b. Thus, the wafer W is transferred from the wafer carrying arm 14a to the support members 48.

[0049]

After the wafer carrying arm 14a has been withdrawn from the resist

modification unit (VOS) 15a, the rod lifting mechanisms 50 are operated to lower the support members 48 to place the wafer W at a predetermined processing position and to close the through holes 47 with the bodies 48a of the support members 48, respectively. Subsequently, the cover 41b is lowered and is brought into close contact with the lower vessel 41a. Then, the locking mechanism 35 is operated to join the lower vessel 41a and the cover 41b firmly together in order to hermetically close the chamber 30.

[0050]

The heaters 39a and 39b of the lower vessel 41a and the cover 41b are energized to keep the central parts of the stage 44a of the lower vessel 41a and the cover 41b at predetermined temperatures, respectively. For example, the stage 44a is heated at 100°C, while the cover 41b is heated at 110°C. Thus, the condensation of steam is prevented when the processing gas containing steam and ozone is supplied into the substrate chamber 30. The density of steam in the substrate chamber 30 is higher in the vicinity of the stage 44a than in the vicinity of the cover 41b. Thus, steam can be efficiently applied to the wafer W.

[0051]

If the difference between the respective temperatures of the stage 44a and the cover 41b is excessively large, steam tends to condense on the stage 44a and the wafer W. If the difference between the respective temperatures of the stage 44a and the cover 41b is small, there will be no difference in steam density between a space over the wafer W and a space under the wafer W. Therefore, the temperature difference between the stage 44a and the cover 41b is between 5°C and 15°C, preferably, 10°C.

[0052]

After the stage 44a and the cover 41 have been stabilized respectively at the predetermined temperatures, and temperature

distribution on the wafer W has become uniform, a mixed gas of ozone and nitrogen is supplied through the processing gas supply port 46a into the chamber 30 to purge the chamber 30 and to keep the pressure in the chamber 30 at a predetermined positive pressure of, for example a gage pressure of 0.2 MPa. A processing gas, namely, a mixed gas of the mixed gas of ozone and nitrogen, and steam, is supplied into the chamber 30. The processing gas oxidizes the resist film formed on the wafer W to convert the resist film into a water-soluble one. The supply rate at which the processing gas is supplied through the gas supply port 46a and the discharge rate at which the processing gas is discharged through the gas discharge port 46b are properly regulated to keep the interior of the chamber 30 at a predetermined positive pressure. Thus, time necessary for modification the resist film can be reduced and throughput can be improved.

[0053]

While the wafer W is being processed by the resist modification unit (VOS) 15a, since the through holes 47 are sealed by the support members 48 , the processing gas is unable to leak outside from the chamber 30. Even if the processing gas should flow through the through holes 47 by some rare accident, the diaphragms 56 prevents the processing gas from leaking outside from the chamber 30. Thus, the devices and the processing units installed in the processing station 2 are prevented from the damaging effect of the processing gas.

[0054]

After the completion of the resist modification process, the supply of the processing gas is stopped. Then, nitrogen gas is supplied by the processing gas supply device 16 into the chamber 30 to purge the chamber 30 with the nitrogen gas. After the completion of the purging process with the nitrogen gas, it is confirmed that the internal pressure of the substrate chamber 30 is equal to the external atmospheric pressure.

It is possible that the chamber 30 is damaged if the substrate chamber 30 is opened when the internal pressure of the substrate chamber 30 is higher than the atmospheric pressure. After the confirmation of the internal pressure of the chamber 30, the locking mechanism 35 is operated to unlock the fastening of the lower vessel 41a and the lid 40b, and then the cover 41b is raised. Subsequently, the rod lifting mechanisms 50 are operated to raise the support members 48. Then, the wafer carrying arm 14a advances into a space under the wafer W, and thereafter rises to lift up the wafer W from the support members 48.

[0055]

The resist modification process performed by the resist modification unit (VOS) 15a converts the resist film into a water-soluble one but does not remove the resist film from the wafer W. Thus, in order to remove the resist from the wafer W, the wafer W is delivered to any one of the cleaning units (CLN) 12a to 12d and is subjected to a resist removing process using a cleaning liquid.

[0056]

The wafer W cleaned by one of the cleaning units (CLN) 12a to 12d is delivered to any one of the hot plate units (HP) 19a to 19d to be heated and dried. Then, the wafer W is delivered to one of the cooling plate units (COL) 21a and 21b to be cooled. The wafer W cooled at a predetermined temperature is conveyed to the wafer holding unit (TRS) 13a, and then is conveyed to a predetermined position in the carrier C.

[0057]

A chamber 30a in another embodiment applicable to the resist modification unit (TRS) 15a will be described. Fig. 9 shows the chamber 30a in a schematic sectional view. The chamber 30a has a lower vessel 41a, which is the same in construction as the lower vessel 41a of the chamber 30. The chamber 30a has substrate support mechanisms 33 for

transferring a wafer W between the same and a wafer conveying arm 14a. Each substrate support mechanism 33 includes a support member 63 for supporting the periphery of a wafer W, a substrate support rod 64 inserted in a through hole 47 and connected to the support member 63, and a spring mechanism 65 for holding the support rod 64.

[0058]

The support member 63 is the same in construction as the body 48a of the support member 48. When the support member 63 is pushed toward the through hole 47 by a pressing member 74 (described later), the through hole 47 is closed in an airtight fashion.

[0059]

The spring mechanism 65 includes a cylindrical member 71 having a cylindrical interior space, a lifting rod 72 arranged in the interior space, and a spring 73 biasing the lifting rod 72 upward. The cylindrical member 71 is attached to the lower surface of the lower vessel 41a so as to bring the interior space of the cylinder member 71 into communication with through hole 47 formed in the lower vessel 41a. The lifting rod 72 is connected to the support rod 64. The cylinder member 71 and the lifting rod 72 constitute a bedding structure through a bearing 75.

[0060]

The lifting rod 72 is passed through the spring 73 to function as a guide shaft for vertically holding the spring 73. A biasing force of the spring 73 is applied to the upper part of the lifting rod 72. Thus, the lifting rod 72 has different outer diameters. The bottom wall of the cylindrical body 71 is provided with a through hole of a diameter slightly greater than the diameter of a lower end portion of the lifting rod 72 to guide the lifting rod 72.

[0061]

When a cover 41b is withdrawn upward, the spring 73 urges the lifting rod 72 upward. However, as the projection part is formed in

the lower end portion of the support rod 64, the projection part comes into contact with the exit portion of a small diameter part of the through hole 47, so that the support rod 64 can no longer move upward. Thus the upper limit position of the support member 63 is determined.

[0062]

The pressing members 74 are attached to the lower surface of the cover 41b. When the cover 41b is lowered, the pressing members 74 come into contact with the support members 63, and lower the support members 63, the support rods 64 and the lifting rods 72 simultaneously, compressing the springs 73. In Fig. 9, continuous lines indicate a state where the cover 41b has been lowered and joined to the lower vessel 41a, the support members 63 has been completely pushed downward by the pressing members 74 and the through holes 47 have been closed. In Fig. 9, doted lines indicate a state where the cover 41b has been moved away from the lower vessel 41a and the support members 63 have been raised by the springs 73.

[0063]

Advantageously, the spring mechanisms 65 are simple in construction, do not need any mechanism corresponding to the air supply mechanisms needed by the rod lifting mechanisms 50 as previously described, which facilitates a control when a wafer W is processed.

[0064]

While the pressing members 74 is in contact with the support members 73, the pressing members 74 serve as guides for restraining a horizontal movement of a wafer W. Diaphragms 76 for secondarily preventing the leakage of the processing gas through the through holes 47 is fixed on a lower part of the support rod 64. A periphery of the diaphragm is held between the cylinder 71 and the lower vessel 41a.

[0065]

Fig. 10 shows a chamber 30b in another embodiment according to

the present invention in a schematic sectional view. The chamber 30B has a lower vessel 81a and a cover 81b. The cover 81b can be vertically moved by a lifting mechanism 82. The left half part of Fig. 10 shows a state where the cover 81b is separated from the lower vessel 81a and is withdrawn upward, and the right half part of Fig. 10 shows a state where the cover 81b is closely joined to the lower vessel 81a.

[0066]

O-rings 84 are placed on the upper surface of a peripheral part of the lower vessel 81a. A peripheral part of the cover 81b compresses the O-rings 84 to seal the joint of the cover 81b and the lower vessel 81a when the cover 81b is lowered to form a sealed processing space 34 in the substrate chamber 30b. The lower vessel 81a is provided with a gas supply port 83a through which a processing gas is supplied into the processing space 34, and a gas discharge port 83b through which the processing gas is discharged from the processing space 34.

[0067]

Wafer support mechanisms 36 attached to the lower vessel 81a support a wafer W in the substrate chamber 30B. Each wafer support mechanism 36 includes: a base 85 fixed to the lower vessel 81a; a support plate 86 on which a wafer W is seated; and a telescopic, stretchable rod 87 having a lower end fixed to the base 85 and an upper end fixed to the support plate 86; a spring 88 surrounding the stretchable rod 87 and having a lower end connected to the base 85 and an upper end connected to the support plate 86; and an pressing member 89 having a substantially L-shaped cross section, attached to the support plate 86 and capable of being brought into contact with and of being separated from the cover 81b. [0068]

Preferably, a pin having a small diameter projects from the upper surface of the support plate 86. The pin comes into contact with a part, having a small area, of the wafer W, which is effective in suppressing

the contamination of the back surface of the wafer W. In a state where the cover 81b is withdrawn upward, the support plate 86 is raised and is held at a predetermined height by the resilience of the spring 88 (See the left half part of Fig. 10). In this state, a wafer W can be transferred between the wafer carrying arm 14a and the support plates 86.

[0069]

When the cover 81b is lowered, the pressing members 89 are depressed by the cover 81b. Consequently, the support plates 86 connected to the pressing members 89 move downward, compressing the springs 88. When the cover 81b is held in the vicinity of the lower vessel 81a, a height of the support plate 86 is determined as shown in the right half part of Fig. 10. Thus, a processing space 34 is formed, and a processing gas is supplied thereinto to subject a resist film formed on a wafer W to a resist modification process.

[0070]

If the springs 88 are self-supportable, the stretchable rods 87 may be omitted. Preferably, the component members of the wafer support mechanisms 36 are formed of materials resistant to the corrosive action of the processing gas. It is also preferable to coat the surfaces of those members with a material resistant to the corrosive action of the processing gas.

[0071]

Heaters 69a and 69b are embedded in the lower vessel 81a and the cover 81b, respectively, to heat a wafer W at a predetermined temperature. In addition, a recess 90 is disposed in the cover 81b such that the pressing members 89 comes in contact with the bottom of the recess 90 to thereby reduce a volume of the processing space 34. Thus, a flowrate amount of the processing gas can be reduced, and a throughput can be improved.

[0072]

Fig. 11 shows a chamber 30c in another embodiment according to the present invention in a schematic sectional view. The chamber 30c has a lower vessel 91a and a cover 91b. The cover 91b can be moved vertically by a lifting mechanism 92. A state where the cover 91b is raised to be separated from the lower vessel 91a is shown in the left half part of Fig. 11, and a state where the cover 91b is joined closely to the lower vessel 91a is shown in a right half part of Fig. 11.

[0073]

O-rings 94 are placed on the upper surface of a peripheral part of the lower vessel 91a. When the cover 91b is lowered, the lower surface of a peripheral part of the cover 91b compresses the O-rings 94 so that the lower vessel 91a and the cover 91b are hermetically joined, thereby a sealed processing space 37 is formed in the chamber 30C. The lower vessel 91a is provided with a gas supply port 93a for supplying a processing gas into the processing space 37, and a gas discharge port 93b for discharging the atmosphere in the processing space 37. A plurality of through holes 95 are formed in the bottom wall of the lower vessel 91a.

[0074]

In the substrate chamber 30b, a wafer lifting device 38 supports and vertically moves a wafer W. The wafer lifting device 38 includes a lifting plate 96 vertically moved by a lifting mechanism 96a, support plates 98 for supporting a wafer W thereon, support rods 97 connecting the support plates 98 to the lifting plate 96 and extending via through holes 95 formed in the lower vessel 91a, support pins 98a projecting from the surfaces of the support plates 98, and bellows 99 for preventing a processing gas from leaking outside from the substrate chamber 30C through the through holes 95. Each of the bellows 99 surrounds the support rod 97 and has opposite ends hermetically connected to the lower surface of the lower vessel 91a and the upper surface of the lifting plate 96, respectively.

[0075]

Sealing rings 95a are placed in each through hole 95. The sealing rings 95a permits the smooth vertical movement of the support rod 97 and prevents the processing gas from leaking outside from the substrate chamber 30C through the through hole 95.

[0076]

When the cover 91b is raised to be separated from the cover 91a, the lifting mechanism 96a is able to move the lifting plate 96 upward. Thus, the bellows 99 are forced to contract, and the support plates 98 are spaced a predetermined vertical distance apart from the lower vessel 91a (See the left half part of Fig. 11). In this state, a wafer W can be transferred between the wafer carrying arm 14a to the support plates 98.

[0077]

When the lifting mechanism 96a lowers the lifting plate 96 and the support plates 98, the cover 91b can be lowered and can be joined closely to the lower vessel 91a. Thereby, a processing space 37 is formed, and a wafer W is held in the processing space 37 (See the right half part of Fig. 11).

[0078]

Heaters 79a and 79b are embedded in the lower vessel 91a and the cover 91b, respectively, to heat a wafer W at a predetermined temperature. After the temperature of the wafer W reaches the predetermined one, a processing gas is supplied into the processing space 37 to process a resist film formed on the wafer W by a resist modification process.

[0079]

Although the invention has been described in its preferred embodiments, the present invention is not limited thereto in its practical application. For example, in the chamber 30, a support pin for supporting a wafer W may be disposed on a surface of the stage 44a of the lower

vessel 41a. With this structure, the support members 48 supporting the wafer W is lowered, the wafer W is transferred therefrom to the support pin, and then the support members 48 move further down and closes the through holes 47. Further, the substrate chambers 30a to 30b may be provided with the locking mechanism 35.

[0080]

Although the invention has been described on an assumption that the workpiece is a semiconductor wafer, the workpiece is not limited thereto. The present invention may be applied to a removing process of a resist used when manufacturing an electric circuit in a glass substrate for a liquid crystal display (LCD).

[0081]

[Effect of the Invention]

As apparent from the foregoing description, the substrate chamber of the present invention does not need any member corresponding to the long substrate support pins, permanently projecting into the processing space, of the conventional substrate chamber. Therefore, the substrate chamber can be designed such that a thin processing space having a small volume and conforming to the shape of a substrate is defined therein. Thus the amount of the processing gas to be supplied into the substrate chamber can be reduced and the processing gas can be effectively used. Consequently, the running cost of the substrate processing system can be reduced and the throughput can be increased. When the substrate chamber is provided with a heater, the substrate can be quickly heated in a highly uniform temperature distribution. Consequently, the quality of the processed substrate can be improved and the throughput can be increased. Since the leakage of the processing fluid from the substrate chamber is prevented by a simple structure, the substrate chamber including the auxiliary parts can be formed in a thin structure. Thus, a system built by stacking a plurality of substrate chambers like the substrate chamber

of the present invention can be formed in s small size.

[Brief Description of the Drawings]

[Fig. 1]

A schematic plan view of a resist removing system.

[Fig. 2]

A schematic front view of the resist removing system.

[Fig. 3]

A schematic rear view of the resist removing system.

[Fig. 4]

A schematic sectional view of an embodiment of a chamber provided in a resist modification process unit (VOS).

[Fig. 5]

Another schematic sectional view of the chamber shown in Fig. 4.

[Fig. 6]

An enlarged sectional view of a periphery of the chamber shown in Fig. 4.

[Fig. 7]

A schematic plan view of an arrangement of a locking mechanism of the chamber.

[Fig. 8]

A view for explaining a motion of a clamping roller of the locking mechanism shown in Fig. 7.

[Fig. 9]

A schematic sectional view of a further embodiment of a chamber provided in the resist modification process unit (VOS).

[Fig. 10]

A schematic sectional view of a still further embodiment of a chamber provided in the resist modification process unit (VOS).

[Fig. 11]

A schematic sectional view of another embodiment of a chamber provided in the resist modification process unit (VOS).

[Fig. 12]

A schematic sectional view of a structure of a conventional chamber.

[Reference Characters]

1; resist removing system

2; process station

3; transfer station

4; carrier station

15a to 15h; resist modification process unit (VOS)

30; chamber

31a, 31b; air supply mechanism

32; processing space

35; locking mechanism

36; wafer supporting mechanism

38; wafer lifting mechanism

39a, 39b; heater

41a; lower vessel

41b; lid

47; through hole

48; support member

49; support rod

50; rod lifting mechanism

51; cylinder

52; lifting rod

54a, 54b; space

55a; first air inlet/outlet port

55b; second air inlet/outlet port

65; spring mechanism

73; spring

74; pressing member

86; support plate

88; spring

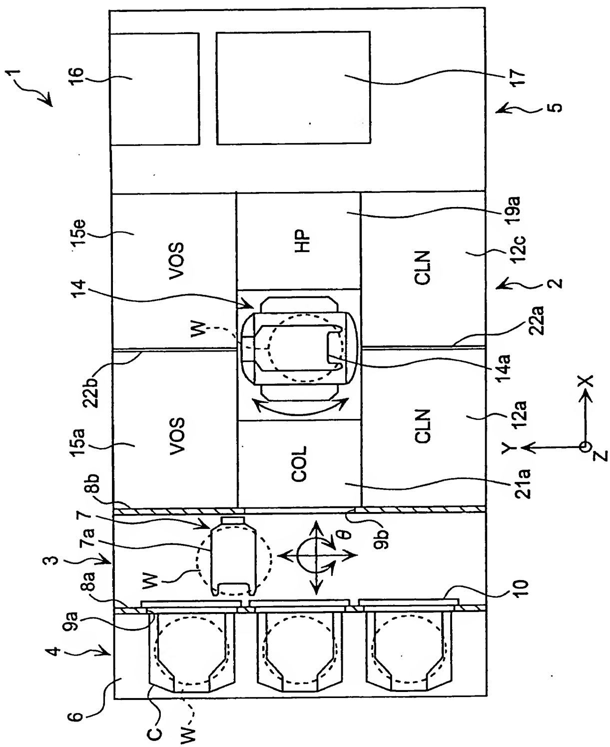
89; pressing member

W; wafer (substrate)

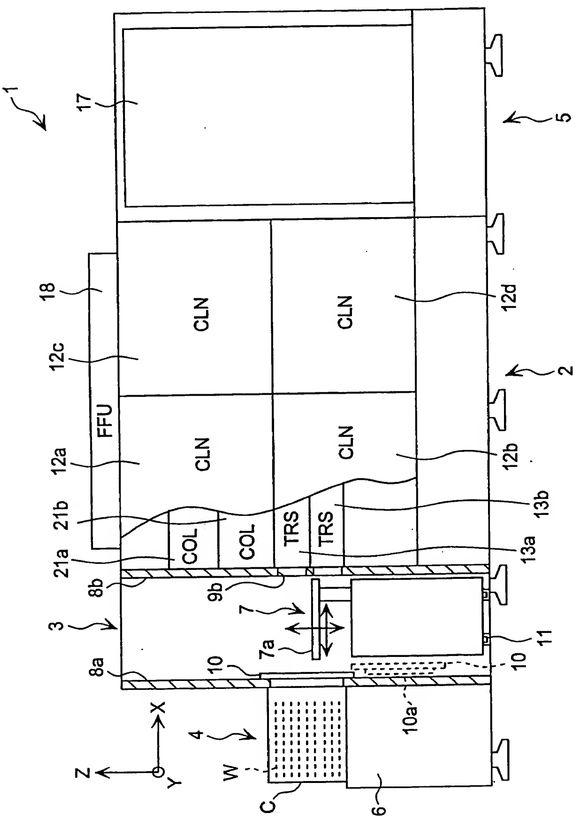
【書類名】　　　図面

【図１】

Fig. 1



【図２】 Fig. 2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18
12c
CLN
CLN
12d
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FFU
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TRS
13b
21a
13a
8b
9b
7
3
7a
11
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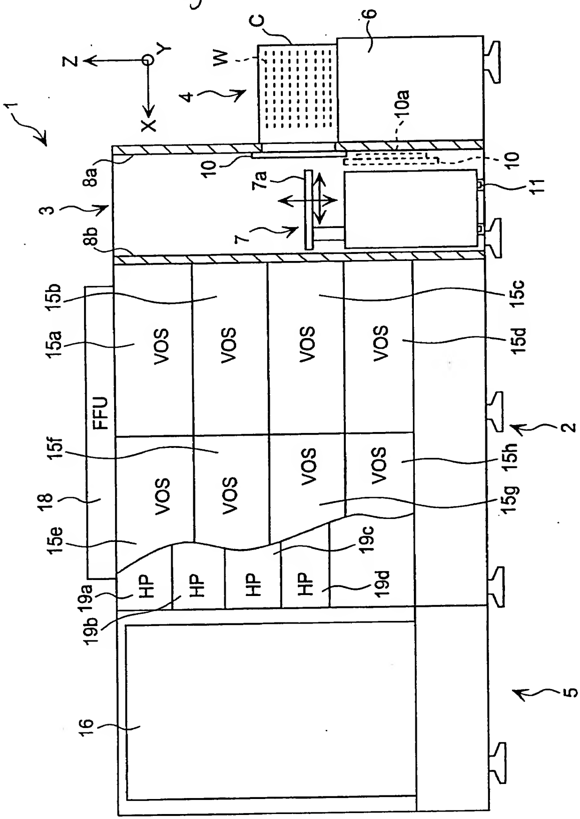
10
8a
10a
X
Z
Y
4
W
C
6

【図３】

Fig. 3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W
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10
1
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7
8b
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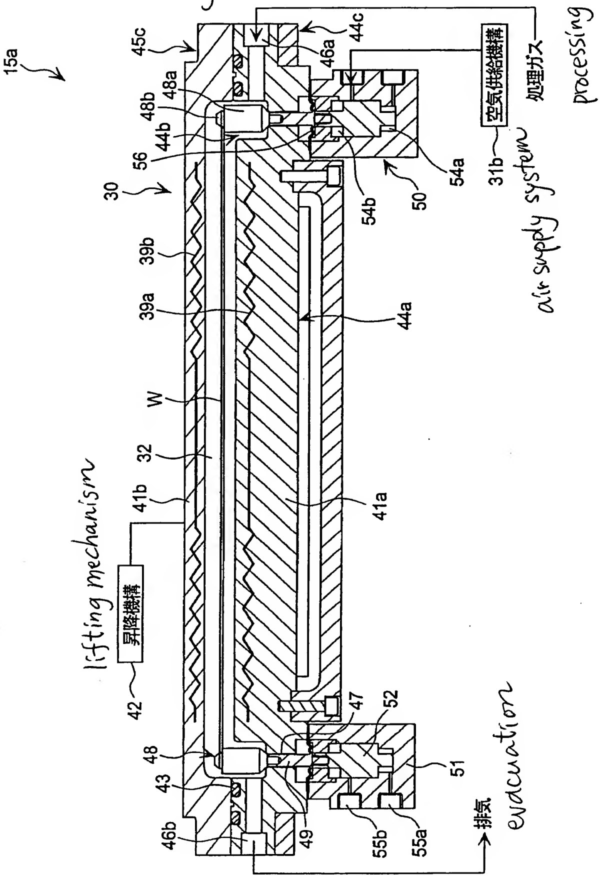
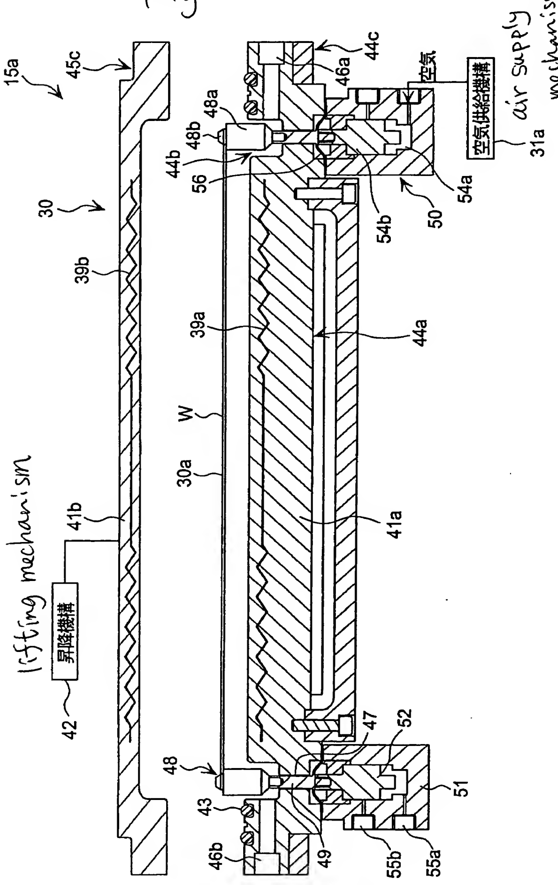
15c
15d
VOS
FFU
15f
18
15e
15h
15g
2
HP
19a
19b
19c
19d
16
5

【図４】

Fig. 4

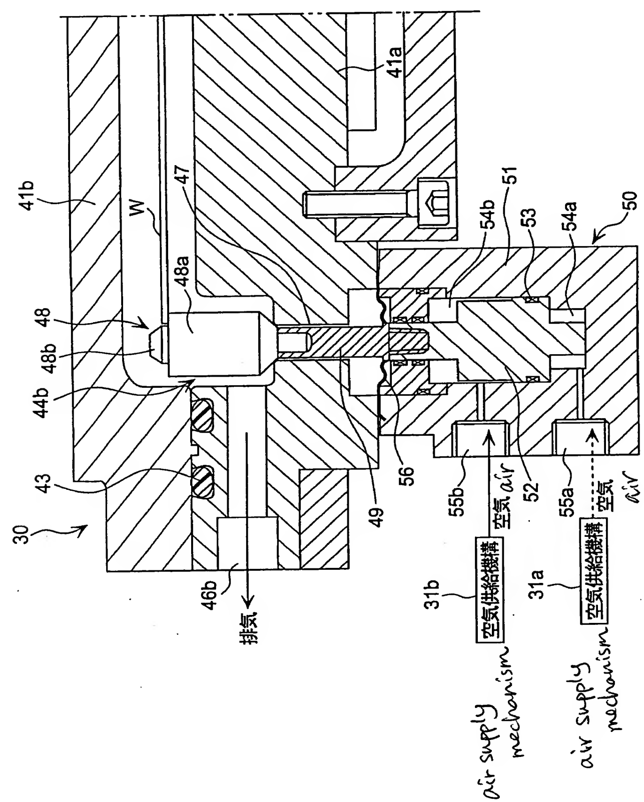

15a
45c
44c
46a
48a
48b
44b
56
空気供給機構
処理ガス
processing gas
31b
air supply system
54a
50
54b
30
39b
39a
44a
W
32
41b
41a
lifting mechanism
昇降機構
42
47
52
48
43
51
49
46b
55b
55a
排気
evacuation

【図５】 Fig. 5


15a
45c
30
39b
41b
42
昇降機構
lifting mechanism
48a
48b
44b
56
39a
W
30a
44c
46a
空気
空気供給機構
air supply mechanism
31a
54a
50
54b
44a
41a
47
52
51
48
43
46b
49
55b
55a

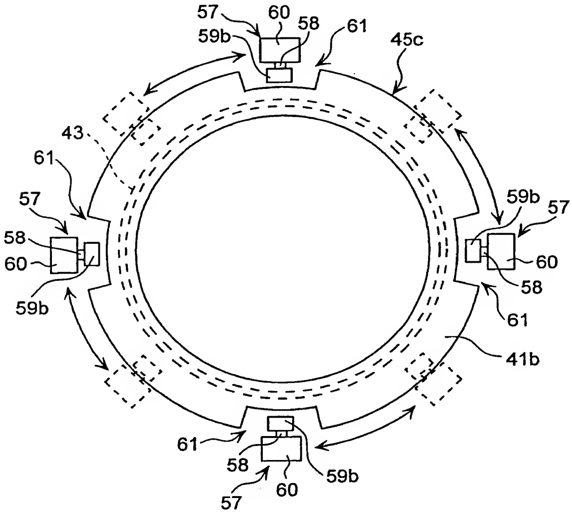
【図６】

Fig. 6


41a
41b
W
47
51
50
54b
53
54a
48a
48
48b
44b
43
30
49
56
52
55b
55a
空気 air
空気 air
46b
排気
31b
31a
空気供給機構
空気供給機構
air supply mechanism
air supply mechanism

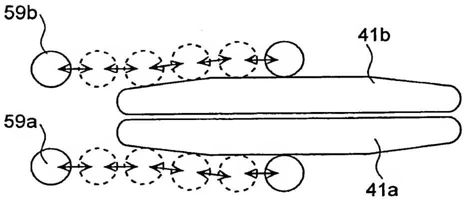
【図７】

Fig. 7



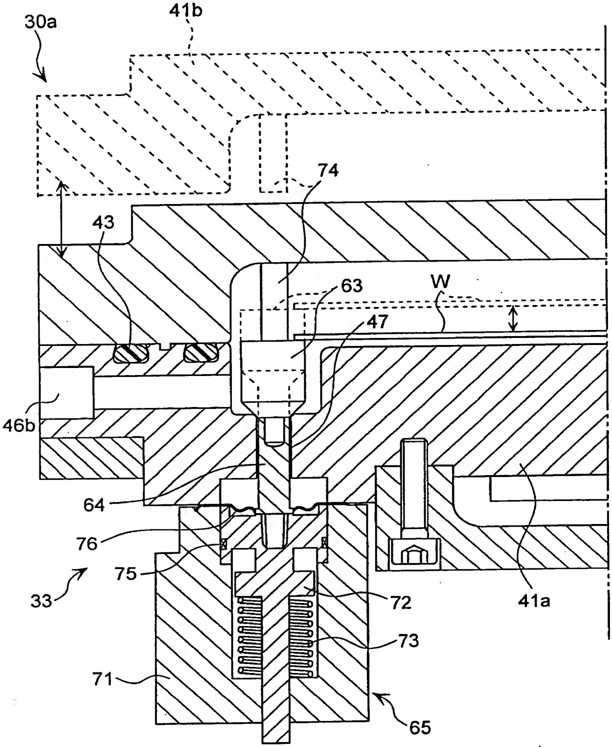
【図８】

Fig. 8

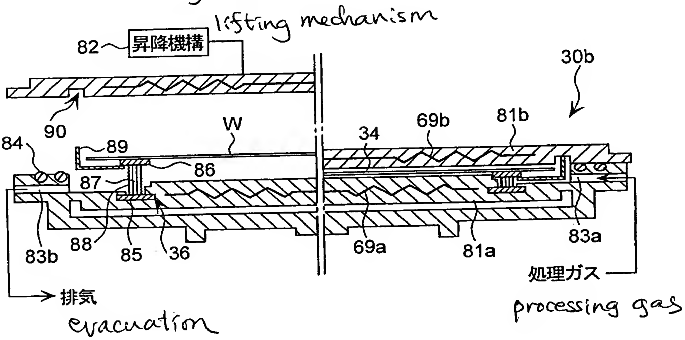


【図９】

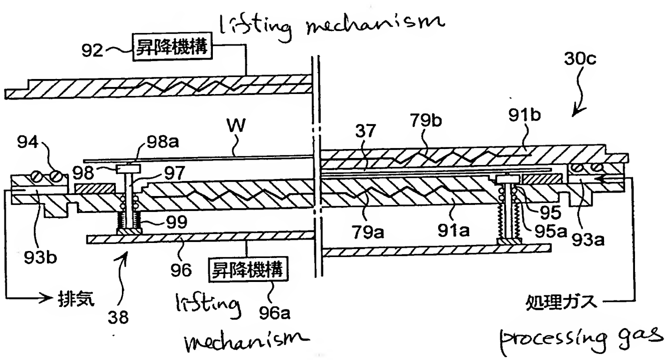
Fig. 9



【図１０】 Fig. 10

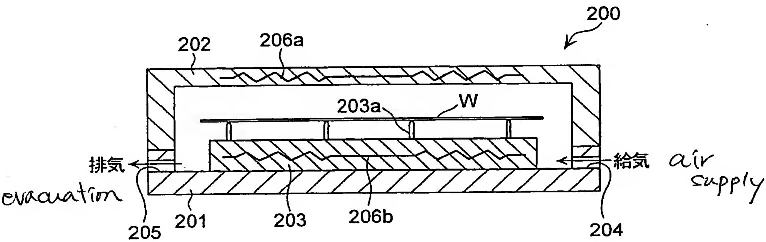


【図１１】 Fig. 11



【図１２】

Fig. 12


200
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206a
203a
W
排気
evacuation
給気
air supply
205
201
203
206b
204

[Document Type] Abstract

[Abstract]

[Object]

To provide a substrate processing chamber low profile and in a small internal volume.

[Means for Solving the Problem]

A chamber 30 includes a lower vessel 41a and a lid 41b. Through holes 47 are formed in the lower vessel 41a. A support rod 49, which is provided at the tip thereof with a support member 48 for supporting a wafer W thereon, is arranged in each of the through holes 47. The support rod 49 is capable of vertically moving by a rod lifting mechanism 50. When the support rod 49 is lowered to hold the support member 48 at the lowest end, the through holes 47 are sealed by the support member 48 in a airtight fashion, and the wafer W is accommodated in a processing space 32 which is small in thickness and is formed by the lower vessel 41a and the lid 41b.

[Selected Drawing]

Fig. 4